



REQUEST FOR INFORMATION (RFI)
No. 5000045295

Date: October 15, 2019

File #: R707.1

Subject: Request for Information (RFI) regarding Project *“Review of the Basis for Establishing Probabilistic Fracture Mechanics Acceptance Criteria”*

1. Background and Purpose of this RFI

The purpose of this RFI is to obtain information before finalizing the requirements definition and procurement strategy for the subject project which is being carried out by the Canadian Nuclear Safety Commission (CNSC).

The details of the project and requirements are further outlined in Annex “A” – Statement of Work to this RFI.

2. Nature of this RFI

This Request for Information (RFI) is simply intended to solicit feedback from industry with respect to the matters described in this RFI and shall not be construed to be a bid solicitation and no agreement/contract will be entered into with/awarded to any vendor based on responses to this RFI, and it shall in no way be considered as authorization by Canada for vendors to undertake any work. This RFI shall in no way be considered as authorization by the CNSC for respondents to undertake any work, which would result in costs to the CNSC. The CNSC shall not be liable for, nor shall it reimburse any of the respondents, or any third-party, for any costs, fees or expenses, incurred in the preparation or submission of a response to this RFI.

Nothing in this RFI shall be construed as a commitment to issue a bid solicitation. Response to this RFI will not create any obligation. The CNSC shall not be bound by anything stated herein. Respondents shall not be bound by any aspect of their response to this RFI.

3. Nature and Format of Responses Requested

Respondents are requested to provide their responses to questions in Section 5.

4. Treatment of Responses

- a) **Use of Response:** Responses will not be formally evaluated. All responses to this RFI will be held by the CNSC on a confidential basis (subject to applicable legislation) and remain the property of the CNSC once they have been received. Respondents are advised, however, that information submitted may be used in the development of future bid solicitation documents. CNSC will review all responses received by the RFI closing date. CNSC may, in its discretion, review

responses received after the RFI closing date. Not responding to this RFI shall in no way penalize bidders to any future bid solicitation.

- b) **Confidentiality:** Respondents should mark any portions of their response that they consider proprietary or confidential. The CNSC will handle the responses in accordance with the *Access to Information Act*.
- c) **Follow-up Activity:** The CNSC may contact any respondents to follow up with additional questions or for clarifications of any aspect of a response.

5. Questions to Interested Parties of this RFI

- 1) Would you/your organization be able to provide the services outlined in Annex “A” – Statement of Work (SOW) and be interested in bidding on any solicitation that may be issued related to the SOW?
- 2) Could the work be completed within the estimated dates related to the deliverables/milestones in the SOW and an estimated budget of \$60,000.00 Canadian dollars, excluding applicable taxes but all-inclusive of travel etc.?
- 3) What would the estimated level of effort be to complete the work (in person days)?
- 4) What types of resources (human and otherwise) are required to complete the work including experience and qualifications?
- 5) Is the Statement of Work clear and reasonable?
- 6) Do you have any general comments or concerns regarding the SOW and/or suggestions for improvements to the SOW?

6. Submission of Responses to Questions to Interested Parties

- a) **Response addressee:** Responses are to be sent by email to:

cnsolicitation-demandedesoumission.ccsn@canada.ca

- b) **Closing Date for Submission of Responses:** Suppliers interested in providing a response shall submit their responses no later than 2:00 PM (EST), Tuesday November 5th, 2019.
- c) **Responsibility of Timely Delivery:** Each respondent is solely responsible for ensuring its response is delivered on time per the instructions specified in this RFI.
- d) **Language of Response:** Responses may be in English or French at the preference of the respondent.

7. Response Preparation Costs

CNSC will not reimburse any respondent for expenses incurred in responding to this RFI.

8. Enquiries

Because this is not a bid solicitation, the CNSC will not necessarily respond to enquiries in writing or circulate answers to all potential suppliers/respondents. However, respondents with questions regarding the RFI may direct their enquiries by email to cnscc.solicitation-demandedesoumission.ccsn@canada.ca.

ANNEX “A” – STATEMENT OF WORK

1.0 Title

Review of the Basis for Establishing Probabilistic Fracture Mechanics Acceptance Criteria (R707.1)

2.0 Objectives

The Contractor must address the following objectives:

- 2.1 Summarize the review of efforts described in public domain documents to develop acceptance criteria for PFM applications. Highlight commonalities and differences in considerations that form the basis for the acceptance criteria.
- 2.2 Provide recommendations to CNSC staff concerning the adoption or development of acceptance criteria for PFM evaluations for different applications considering the regulatory requirements associated with Defence-in-Depth principles applied to nuclear power plants.
- 2.3 If applications require the development of acceptance criteria that satisfy safety margins in existing, deterministic based design codes, provide recommendations to CNSC staff to assist in establishing a measure of equivalence between existing deterministic and proposed probabilistic acceptance criteria.
- 2.4 Provide a summary of any inconsistencies in the development or use of PFM acceptance criteria observed in public domain documentation describing PFM assessments for nuclear industry applications and discuss the potential implications of these inconsistencies in terms of the current Canadian NPP licensing basis.
- 2.5 Provide guidance to CNSC staff to ensure that acceptance criteria are based upon appropriate reliability theory principles and a discussion of the consequences of not adhering to those principles.

3.0 Background

Because of perceived conservatism identified in deterministic fracture mechanics applications adopted by codes, standards and guidelines used for nuclear power plant (NPP) pressure boundary component evaluations, the nuclear industry continues to investigate the adoption of probabilistic fracture mechanics (PFM) methodologies. There has been a great deal of focus on the development of PFM software tools and verification and validation of those tools. While challenges still remain in those areas, there appears to have been considerably less effort spent on the development of the technical basis for acceptance criteria that can be adopted by industry codes, standards and regulations. To date, development of acceptance criteria appears to be treated on an ad-hoc basis.

When new applications for the use of PFM to assess the effects of pressure boundary component aging are conceptualized, regulatory bodies must consider acceptance criteria that establish safety margins consistent with the licensing basis for NPPs. At this time regulations, standards and codes generally do not prescribe acceptance criteria that would permit a straightforward application of PFM evaluations to satisfy licensing requirements for NPPs. Decisions related to acceptable failure frequencies or probabilities are often considered on a scenario specific basis.

When establishing acceptance criteria for regulatory decisions, CNSC staff must consider the intent of the application in relation to the appropriate level of Defence-in-Depth. The five levels of Defence-in-Depth described in REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* can be summarized as follows:

Level 1: Prevent deviations from normal operation and prevent failures of structures, systems and components (SSCs) important to safety

Level 2: To detect and intercept deviations from normal operation, in order to prevent anticipated operational occurrences (AOOs) from escalating to accident conditions and return the plant to state of normal operation

Level 3: Minimize the consequences of accidents by providing inherent safety features, fail-safe design, additional equipment and mitigating procedures

Level 4: Ensure radioactive releases caused by severe accidents are kept as low as practical

Level 5: Mitigate radiological consequences of potential release of radioactive materials that may arise from accident conditions

To put this into perspective, a fracture mechanics evaluation used to demonstrate the structural integrity of a pressure boundary component would fall under Level 1. Demonstrating that a component containing a flaw will withstand applied loading while maintaining the safety margins inherent in the design code could be the objective of this type of evaluation. A fracture mechanics evaluation to support a Loss of Coolant Accident (LOCA) safety analysis assessment would fall under Level 3 or Level 4. Such an evaluation could include demonstrations that double-ended guillotine pipe breaks are highly unlikely under design basis loading conditions or demonstrations that expected component failure frequencies or probabilities are sufficiently low such that target Core Damage Frequencies or Large Release Frequencies would not be exceeded. While Level 3 or 4 acceptance criteria can often be directly related to probabilistic or reliability based parameters, current design codes generally do not express safety margins in terms of probability or reliability, which can complicate the adoption of PFM based assessments for Level 1 structural integrity evaluations.

In addition to regulatory framework considerations adherence to reliability theory principles must also be considered. For example, the treatment of a system or component as a repairable or non-repairable system, which in the context of reliability theory, can impact the appropriate parameter that should be used as the basis for acceptance criteria (cumulative probability, failure rate, failure frequency, hazard rate, etc.).

CNSC staff have observed that many publications in the public domain offer conflicting descriptions of acceptance criteria proposed for PFM based evaluations because Defence-in-Depth and reliability theory concepts are not rigorously considered. A value of 1×10^{-6} is often quoted as the numerical value associated with acceptance criteria, but in some publications the value is quoted as an annual frequency of failure and in others it can be referred to as a cumulative probability of failure for the life of a component. In some instances, the value of 1×10^{-6} is used as an acceptance criterion for analyses where the endpoints of the assessments may be different. For example, the endpoint may be based upon the frequency of through wall crack formation or as the frequency of component rupture. These endpoints are not necessarily the same if it can be demonstrated that a stable through wall crack is possible without immediately progressing to a rupture.

4.0 Scope of Work

The Contractor must carry out a review of publically available documentation from a variety of sources to achieve the objectives stated above. The review must include a summary of international nuclear industry activities related to:

- Guidance for the development of acceptance criteria for PFM evaluations
- Defence-in-Depth considerations in the development of acceptance criteria
- The application of reliability theory concepts to support the development of appropriate acceptance criteria
- Recommendations for improvements to ensure consistency in the development of acceptance criteria meeting CNSC regulatory requirements

The Contractor must prepare a final report documenting the results of the review addressing the project objectives.

Documents that can be used as starting points for the review are suggested below:

- CNSC REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*
- CNSC REGDOC-2.4.1, *Safety Analysis: Deterministic Safety Analysis*
- CNSC REGDOC-2.4.2, *Safety Analysis: Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*
- CSA Standard N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors*
- US Nuclear Regulatory Commission NUREG-1874, *Recommended Screening Limits of Pressurized Thermal Shock (PTS)*
- Draft Document: *Important Aspects of Probabilistic Fracture Mechanics Analysis*, P. Raynaud, M. Kirk, M. Benson and M. Homiack
- Electric Power Research Institute Materials Reliability Program MRP-362, *Technical Basis for ASME Section XI Code Case on Flaw Tolerance of Cast Stainless Steel (CASS) Piping*
- xLPR Version 2.0 Technical Basis Document, *Acceptance Criteria*
- CNSC Research Report R617.1, *Technical Basis of a Probabilistic Method for PT-CT Contact Assessment*
- American Society of Mechanical Engineers Pressure Vessels and Piping Conference Proceedings

5.0 Tasks to be Performed

The Contractor must:

- 5.1 Prepare a comprehensive list of references describing international efforts that can be used to support the review objectives.
- 5.2 Summarize the extent to which the intent of the different levels of Defence-in-Depth have been considered in the establishment of currently implemented or proposed acceptance criteria for PFM evaluations.
- 5.3 Provide recommendations for CNSC staff when evaluating acceptance criteria for PFM evaluations to ensure that the intent of the levels of Defence-in-Depth are respected.
- 5.4 Summarize work that has been completed to demonstrate the equivalency of probabilistic acceptance criteria to deterministic design margins in nuclear codes and standards and provide recommendations for CNSC staff for the potential future adoption of such acceptance criteria.
- 5.5 Summarize work that has been completed to establish probabilistic acceptance criteria for safety analysis based PFM evaluations and provide recommendations for CNSC staff for the potential future adoption of such acceptance criteria.
- 5.6 Summarize commonalities and inconsistencies in the development or use of probabilistic acceptance criteria for PFM applications discussed in public domain documentation. For inconsistencies identified, provide a discussion of the potential implications of these inconsistencies in relation to regulatory safety margins.
- 5.7 Summarize reliability theory principles relevant to PFM applications that should be considered for nuclear industry applications and provide recommendations to ensure that these principles are respected during the development of PFM acceptance criteria.

6.0 Deliverables

All deliverables are to be submitted to the Project and Technical Authority.

6.1 Start-up Meeting

Date: Within 14 calendar days following award of the contract

Location: The CNSC Head Office, Ottawa OR Via Tele/Videoconference

Purpose: To discuss and clarify the proposed approach, work plan and schedule to ensure achievement of the contract objectives. The contractor must make a presentation with the above purpose in

mind.

6.2 Progress Meetings

Dates: Every 60 calendar days for the duration of the contract

Location(s): The CNSC Head Office, Ottawa OR Via Tele/Videoconference

Purpose: To assess the degree to which the agreed project objectives are being achieved as planned and thus to facilitate timely adjustments (if necessary) to ensure the project success. Progress meetings must be followed by email correspondence summarizing the current status of the project activities and agreements made during the progress meetings.

6.3 First Formal Progress Report

The Progress Report must address the work performed up to the mid-point of the contract, according to the project schedule as agreed upon at the project kick-off meeting. The report must also include the following:

- An executive summary that includes preliminary conclusions and recommendations.
- A table of contents.
- A brief summary of review findings up to that point.

Due Date: Five (5) months following award of the contract

Copies: One electronic copy via email to the Project Authority

6.4 Draft Final Report

Due Date: Eleven (11) months following award of the contract

Copies: One electronic copy via email to the Project Authority

Format and style requirements: As specified in the Final Report except a version readable by Adobe Acrobat Reader DC is not required.

6.5 Presentation

Due Date: Eleven (11) months following award of the contract

Location: The CNSC Head Office, Ottawa

Purpose: To present the project findings, conclusions and recommendations documented in the Draft Report to CNSC staff and interested industry stakeholders.

6.6 Final Report

Due Date: Twelve (12) months following award of the contract

Copies: One electronic copy via email to the Project Authority

6.7 Abstract

Date: Twelve (12) months following award of the contract

Copies: One electronic copy via email to the Project Authority

Format and style requirements: 300 words or less providing a stand-alone statement that conveys the essential information of the Final Report. The abstract shall include the following: a) context; b) purpose/objective of the research; c) approach/scope/method/findings. The abstract shall be written in a style that can be widely understood by the general public. The CNSC reserves the right to modify or translate the Abstract into French or English.

7.0 Format of Deliverables

The Contractor must provide the deliverables in the following formats:

- electronic;
- using font Times New Roman 12;
- MS Office 2010 or later (Word, Project, PowerPoint, Excel, Visio);
- PDF format.

Any electronic files that cannot be read or require major formatting changes when opened are not acceptable and will be returned to the Contractor for correction at their expense. The CNSC reserves the right to distribute the final report publicly at its discretion. CNSC publication number(s) will be provided by the CNSC.

8.0 Language of Work

The contractor must perform and deliver the work in English.

9.0 Travel Requirements

The contractor must give their final presentation at the CNSC head office in Ottawa, ON. Travel may be required from the contractor's location to Ottawa, ON. Travel costs will be included as part of the fixed price value of the contract.

10. Location of Work

All work must be completed at the contractor's location. The contractor must give their final presentation

at the CNSC head office in Ottawa, ON. The start-up meeting and progress meetings (Deliverables 6.1 and 6.2) can take place via tele/videoconference.